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REACTIONS OF DIFFERENTIAL VARIETIES TO THE RICE GALL MIDGE, *ORSEOLIA ORYZAE*, IN ASIA

REPORT OF AN INTERNATIONAL COLLABORATIVE RESEARCH PROJECT

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ABSTRACT

Varieties and breeding lines known to be resistant to the gall midge in some areas of Asia were tested in China, India, Indonesia, Sri Lanka, and Thailand from 1977-1980. Differential reactions were evident, indicating variations in the virulence of gall midge populations in the various countries. Eswarakora derivatives were resistant in Thailand but susceptible in Indonesia; Leuang 152 was resistant in Indonesia but susceptible in Thailand. In India, Eswarakora derivatives were susceptible in Orissa but resistant in Andhra Pradesh. The Leuang 152 and Ob 677 groups were resistant at all test sites except in Thailand and Bihar, India.

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The gall midge, Orseolia oryzae (Wood-Mason), is widely distributed in Asia and parts of Africa but does not occur in the Philippines (Fig. 1). It is a major rice pest in India, Indonesia, Sri Lanka, and Thailand. The degree of gall midge damage appears to be increasing in certain regions. In Thailand, the gall midge, previously a pest in the northeast, is now also occurring in the Central Plains. In India it has been a pest of the wet-season crop but has recently been observed in the winter crop (Kalode and Kasiviswanathan 1976). In Africa, severe incidence of gall midge in Upper Volta causes losses as high as 40% in irrigated rice (Kaung Zan, IRRI, pers. comm.).

Although the gall midge is primarily a pest of wetland, irrigated rice, it has also been reported on dryland rice in China (Li and Chiu 1951) and in deepwater rice (Venu Gopal Rao 1975). It is primarily a pest of Oryza sativa but wild rice species (Israel et al 1963) and weeds (Israel et al 1970) also serve as hosts. The biology of the gall midge was described by Reddy (1967).

Gall midge larvae damage plants by attacking the growing parts. Instead of producing a panicle, the abnormal growth of the leaf sheath forms a gall which resembles an onion leaf (Perera and Fernando 1970).

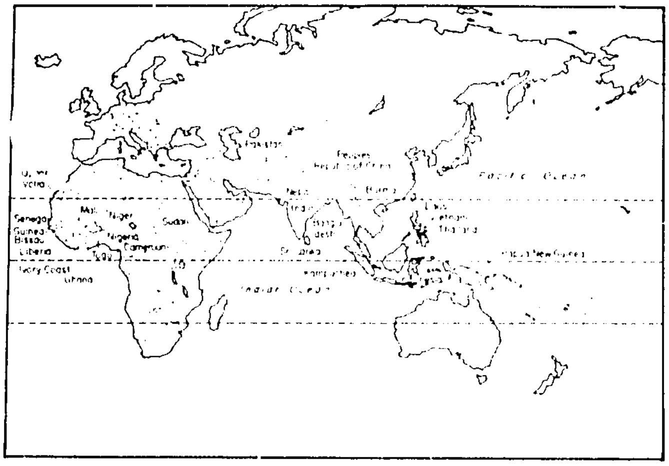

Fig. 1. Geographical distribution of the rice gall midge, *Orseolia oryzae* (Heinrichs and Pathak 1981).

Chemical control of the gall midge has not been highly successful and as a result much emphasis has been placed on the development of resistant varieties. About 200 varieties have been identified as resistant and many of those have been used as sources of resistance in national breeding programs (Heinrichs and Pathak 1981). Breeding programs in India, Sri Lanka, Thailand, and at IRRI have resulted in the release of 15 gall midge-resistant varieties.

Breeding for gall midge resistance has been complicated by the occurrence of biotypes. The definition of "biotypes" herein used is that by Kogan (1975) -- populations of O. oryzae that are capable of damaging and surviving on plants of one variety known to be resistant to other O. oryzae populations. The first recorded incidence of differential reactions to the gall midge was that by Khan and Murthy (1955) who found that HR14 was more resistant than HR8 at Nizamabad in South India. Israel and Vedamoorthy (1953) at Cuttack, 1,200 km to the northeast, found conflicting results. Studies by Roy et al (1971), which simultaneously tested differential varieties at two sites in Orissa -- Cuttack and Sambalpur -- provided additional evidence of the existence of gall midge biotypes. Shastry et al (1972) indicated the existence of biotype variation based on multisite testing in India. Kalode et al (1976) evaluated 28 varieties at Hyderabad and Cuttack. W1263 was resistant at Hyderabad but only moderately resistant at Cuttack. Twenty-two varieties which were resistant at Hyderabad were susceptible at Cuttack. Further studies conducted at 11 sites in India confirmed previous results indicating different reactions to the gall midge in Andhra Pradesh and Madhya Pradesh from those in Orissa state (AICRIP 1978). Kalode (1980) reported different reactions of 4 differential varieties in each state of Orissa, Andhra Pradesh, Madhya Pradesh, and Manipur, India. Fernando (1972) reported that some of the varieties reported as gall midge-resistant at Cuttack, India, were susceptible in Sri Lanka.

The International Rice Gall Midge Nursery (IRGMN), established by IRRI as a part of the International Rice Testing Program (IRTP) in 1975 and grown at sites within Indonesia, India, Sri Lanka, and Thailand, has annually added extensive evidence of several types of differential reactions. In 1977 it became evident that additional emphasis should be given to the identification of the various Asian biotypes as based on reactions of differential varieties. As a result, a collaborative program -- the International Collaborative Gall Midge Biotype Study -- was established between IRRI and national program scientists in China, India, Indonesia, Sri Lanka, and Thailand. The collaborative study seeks to verify the existence of biotypes and determine their distribution. This information provides guidance in the development of breeding strategies by the national programs and IRRI.

MATERIALS AND METHODS

Seeds of differential varieties provided by the national programs and from the IRTP were packaged at IRRI and sent to the collaborators in the test sites (Table 1). Entries tested are given in Table 2. The entries consisted of 8 groups: Leuang 152, Siam 29, and Muey Nawng 62M from Thailand; Ptb and Eswarakora from India; Ptb 18/Eswarakora, Muey Nawng/Eswarakora, and Ptb/Siam 29. Sufficient seed was sent to provide for replication. To increase uniformity of the tests, fieldbooks containing instructions for conducting greenhouse and field screening were sent with the seed. Screening methods varied slightly from site to site but were minor modifications of the following.

Greenhouse screening. In most sites insects were mass reared based on techniques developed by Leaumsang et al (1968) in Thailand, Perera and Fernando (1969) in Sri Lanka, and Kalode et al (1977) in India. Seeds were planted in rows in seedboxes. IR8 and TN1 were used as susceptible checks. Each entry was replicated 3 times if seed was sufficient. When seedlings were about 2 weeks old, they were infested with adult midges for oviposition. The seedboxes containing the infested plants were then placed in a moist chamber with about 90% humidity to provide sufficient moisture for the eggs to hatch. After 4 days exposure to high humidity seedboxes were placed in cages. About 30 days after infestation the total number of plants and number of infested plants were recorded. Percentage of infested plants was calculated as follows:

$$\% \text{ Infestation} = \frac{\text{Number of infested plants}}{\text{Total number of plants}} \times 100$$

Field screening. Planting was timed in coordination with peak natural occurrence of the gall midge at the given sites. Sites considered hot-spots for the gall midge were selected. Each entry was replicated 3 times if seed was sufficient; each replicate consisted of 2 rows about 2 m long. Fertilizer was provided, based on local recommendations, for good plant growth. At least 2 observations were made to coincide with the peak occurrence of galls. Lights were used in some sites to

Table 1. International Collaborative Gall Midge Biotype test sites, 1977-80.

Region	Site and location	Year
East Asia	*China*	
	Guangzhou Guangdong Academy of Agricultural Sciences	1980
Southeast Asia	*Indonesia*	
	Bogor CRIA Experiment Station	1977-80
	Sukamandi CRIA Experiment Station	1978-80
	Thailand	
	Chieng Rai Farmers' Field	1978-80
	Khonkaen Chumpae Rice Experiment Station	1980
	Pan Phan Rice Experiment Station	1979-80
	Phrae Phrae Rice Experiment Station	1977-78, 1980
	Bangkhen Entomology and Zoology Division Rice Division	 1977, 1979 1978
South Asia	*India*	
	Madhya Pradesh CRRS, Raipur	1979
	Orissa CRRI, Cuttack	1978-30
	Karnataka ARS, Mangalore	1979
	Andhra Pradesh AICRIP, Hyderabad ARS, Warangal	 1977-79 1979-80
	Bihar Agricultural College, Ranchi	1980
	Sri Lanka	
	Peradeniya CARI, Gannoruwa	1977, 1979
	Batalagoda CRBS, Ibbagamuwa	1978, 1980

attract ovipositing midges. Where gall midge incidence was low at maximum tillering, plants were cut to induce fresh tillering.

Observations were taken about 30 days after transplanting. Total number of hills, gall-infested hills, total number of tillers, and gall-infested tillers were recorded. For this report, only the total number of hills and the number of gall-infested hills were considered.

$$\% \text{ Infestation} = \frac{\text{Number of infested hills}}{\text{Total number of hills}} \times 100$$

Data for both the greenhouse and field tests were recorded in the fieldbook and a copy sent to IRRI for data summarization.

Test sites. Screening tests were conducted for 4 years, 1977-80. The number of tests and the test sites varied from year to year as indicated in Table 1.

Tests were conducted in India, Indonesia, Sri Lanka, and Thailand every year (Fig. 2). The number of test sites within each country, however, varied considerably from year to year. In some sites the weather was not suitable or gall midge populations were too low to provide for a valid test. In 1977, 5 tests were conducted -- 1 each in Indonesia, India, and Sri Lanka, and 2 in Thailand. All were greenhouse tests except for 1 field test at Phrae, Thailand. In 1978, tests were conducted at 7 sites -- 2 in Indonesia, 2 in India, 2 in Thailand, and 1 in Sri Lanka. In 1979, 11 tests were conducted in 10 sites -- 2 in Indonesia, 4 in Thailand, 4 in India, and 1 in Sri Lanka. In 1980, 1 test was conducted in China, 3 in India, 2 in Indonesia, 4 in Thailand, and 1 in Sri Lanka.

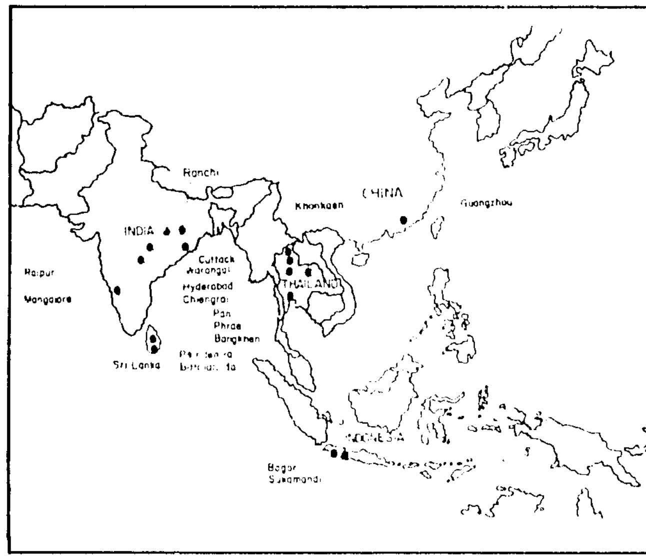

Fig. 2. International Collaborative Gall Midge Biotype study sites.

RESULTS

Reactions of some groups were distinct and without variation from one year to another. Reactions of other groups were less stable at certain sites -- they were resistant one year and susceptible the next. Within countries there were some differences in reactions from one site to another, especially if the test was in a greenhouse in one site and in the field in another. There were also variations within a resistance group which may have been due to different levels of resistance among the varieties which supposedly had sources of resistance from the same donor parent. Despite some variation, definite trends in reactions of the differential varieties at a given site were evident when results of 2 or more years of testing were compared. Where variation was evident, examination of results obtained in the IRGMN from 1976-79 was also considered in classifying the reactions. Results of the 1977, 1978, 1979, and 1980 tests are given in Tables 3 to 6. Table 7 summarizes the reactions at each test site. Tables 8 and 9 summarize the reactions for each country and for sites within India. Reactions of selected entries to other insect pests at IRRI are given in Table 10.

China. Only one greenhouse test was conducted at Guangzhou in extreme Southern China (Table 6). The Leuang 152 and Ob 677 groups were resistant; Siam 29 and Muey Nawng 62M/Eswarakora groups were moderately resistant; and Ptb, Eswarakora, Muey Nawng 62M, and Ptb/Siam 29 groups were susceptible. The reaction of the Eswarakora group in China, however, was not distinct. In the 1978 IRGMN conducted in the field most W1263 and W1263 derivatives were resistant -- they had no infested tillers. However in the 1980 greenhouse test, Kakatiya and the W1263 derivatives were susceptible (Table 6). Further tests are needed to confirm the reaction of Eswarakora and Siam 29 derivatives.

Indonesia. Four greenhouse tests were conducted in Bogor (Tables 3-6) and 2 field tests at Sukamandi (Tables 4-5). In Bogor, the Leuang 152, Siam 29, and Ob 677 groups were resistant and the Ptb, Eswarakora, Muey Nawng 62M/Eswarakora, and Ptb/Siam 29 groups susceptible (Table 7). Muey Nawng 62M was resistant in 1977 and 1979 but susceptible in 1978 and 1980. It was resistant in the 1976, 1977, and 1978 IRGMN and is thus considered as resistant in Table 7. The susceptibility of the Ptb/Siam 29 group indicates that the resistance gene is absent or not functioning because the Siam 29 derivatives are resistant at Bogor. The reactions at Sukamandi were similar except that the Siam 29 derivatives were susceptible. The reaction of the Muey Nawng 62M group varied -- it was susceptible in 1978, resistant in 1977 and 1979, and moderately resistant in the 1976 IRGMN.

Thailand. Four tests were conducted in Bangkhen, 3 at Phrae, 2 at Pan Experiment Station, 2 in a farmer's field near Chieng Rai, and 1 at Khonkaen. The gall midge population in the 1978 test at Phrae (Table 4) was lower than desired for good testing resulting in only 18% infested tillers in the susceptible check IR8. The Leuang 152, Ptb, Siam 29, Ob 677, and Ptb/Siam 29 groups were susceptible at all Thai sites (Table 7). The Eswarakora group was resistant at all sites except at Khonkaen. All entries were susceptible at Khonkaen (Table 6) and in the 1979 IRGMN. Muey Nawng 62M ranged from susceptible at Chieng Rai to moderately resistant at Bangkhen and resistant at Phrae (Tables 5 and 6).

India. Leuang 152, Siam 29, and Ob 677 groups were resistant at all sites except at Ranchi (Table 7).

Table 2. Cultivars tested in the International Collaborative Gall Midge Biotype study, 1977-80.

Designation	Cross	Origin
Leuang 152 group		
Leuang 152	Donor	Thailand
CR95-JR-46-1	Leuang 152/IR8	India
CR95-JR-214	Leuang 152/IR8	India
Ptb group		
Ptb 10	Sel. from Thekkan Checra	India
Ptb 18	Sel. from Eravapandi	India
Ptb 21	Sel. from Thekkan	India
CR157-392-4	Vijaya/Ptb 10	India
CR94-13	Ptb 21/Ptb 18//IR8	India
IR32	IR20*2/O.n.//CR94-13	IRRI
IR36	IR1561-228-1-2/IR1737//CR94-13	IRRI
Eswarakora group		
W1263	MTU 15/Eswarakora	India
WGL 22585	Tella Hamsa/W12708	India
Kakatiya	IR8/W1263	India
BKN6806-18-55	LT/IR8//W1259///RD2	Thailand
BKN6806-46-60	LT/IR8//W1259///RD2	Thailand
BKNBR1031-3-3-6	Puang Nahk 16/Sigadis//RD9	Thailand
IET2893	IR8/W1251	India
IET2895	IR8/W1251	India
RD9	LY*2/TN1//W1256///RD2	Thailand
Siam 29 group		
Siam 29 (Acc 42)	Donor	Thailand
Siam 29 (Acc 5473)	Donor	Thailand
Siam 29 (Acc 5915)	Donor	Thailand
Siam 29 (Acc 5916)	Donor	Thailand
Siam 29 (Acc 36665)	Donor	Thailand
Siam 29 (from Thailand)	Donor	Thailand
CR189-4	CR129-118/RPW 6-13	India
IET2911	IR8/Siam 29	India
Muey Nawng 62 M group		
Muey Nawng 62 M	Donor (Sel. from Muey Nawng)	Thailand
Ob 677 group (Ptb 18/Eswarakora)		
Ob 677	IR8/Ptb 18//Eswarakora/IR8	Sri Lanka
75-159	Ob 677/BG90-2	Sri Lanka
75-203	Ob 678/BG66-1	Sri Lanka
BG401-2	BG94-1*2/Ob 678	Sri Lanka
IET3356	IR8/Ptb 18//Eswarakora/IR8	India
Muey Nawng 62M/Eswarakora group		
BKN1030-3-2	Muey Nawng 62M/IR262//RD9	Thailand
BKN1030-11-2	Muey Nawng 62M/IR262//RD9	Thailand
Ptb/Siam 29 group		
IR4744-128-1-3	RPW6-13/IR1721-11//IR2061-464-2	IRRI
IR8 (susceptible check)	Peta/Dee-geo-woo-gen	IRRI
TN1 (susceptible check)	Dee-geo-woo-gen/Tsai-yuan-chung	Taiwan

Table 3. Reaction of entries in the 1977 Collaborative Gall Midge Biotype study.

Designation	Varietal reaction to gall midge[a]				
	Indonesia	Thailand		India	Sri Lanka
	Bogor GH	Phrae F	Bangkhen GH	Hyderabad GH	Peradeniya GH
Leuang 152 group					
Leuang 152	R (0)	S (38)	S (50)		
Ptb group					
Ptb 18	S (39)	S (23)	S (92)		
Ptb 21	S (46)	S (20)	S (77)	-	R (5)
CR94-13	S (84)	S (33)	S (74)	R (5)	R (0)
IR32	S (82)	S (58)	S (92)	R (0)	R (0)
IR36	S (50)	S (28)	S (94)	R (0)	R (0)
Eswarakora group					
W1263	S (37)	R (3)	MR (7)	R (0)	S (47)
Kakatiya	S (50)	R (0)	S (29)	R (0)	R (0)
BKN6806-18-55	S (58)	R (3)	MR (7)	R (0)	S (43)
BKN6806-46-60	S (85)	R (0)	R (1)	R (0)	S (57)
BKNBR1031-3-3-6	S (75)	R (0)	R (2)	R (0)	S (32)
RD9	S (36)	R (0)	S (18)	-	S (25)
Siam 29 group					
Siam 29	S (55)	S (51)	S (48)	-	S (43)
IET2911	R (0)	S (33)	S (83)	R (0)	R (0)
Muey Nawng 62M group					
Muey Nawng 62M	R (0)	R (0)	S (24)	-	S (60)
Ob 677 group (Ptb 18/Eswarakora)					
Ob 677	MR (6)	S (55)	S (61)	-	R (0)
75-203	S (46)	S (53)	S (80)	-	MR (15)
IET3356	MR (9)	S (63)	S (75)	R (0)	MR (12)
Muey Nawng 62 M/Eswarakora group					
BKNBR1030-3-2	S (81)	R (0)	MR (6)	R (0)	-
Ptb/Siam 29 group					
IR4744-10-2-3	S (19)	S (63)	S (75)	R (0)	S (16)
IR8 (susceptible check)	S (78)	S (55)	S (95)	S (100)[c]	S (86)

[a]Based on percentage (in parentheses) of plants in the greenhouse (GH) or hills in the field (F) infested. R = resistant (0-5% infestation), MR = moderately resistant (6-15% infestation), S = susceptible (16-100% infestation). Replicated 4 times. Reaction of highest replicate used to determine reaction. [b]No data. [c]TN1 used as the susceptible check.

The Eswarakora group, except WGL 22585, was resistant at Raipur, Hyderabad, Warangal, and Ranchi, but susceptible at Cuttack. The Muey Nawng 62M group was moderately resistant at Raipur, resistant at Cuttack, and susceptible at Hyderabad, Warangal, and Ranchi. Because Muey Nawng had 15% hills infested and was extremely susceptible in the 1978 IRGMN, we will consider it susceptible at Raipur (Table 8). The Muey Nawng/Eswarakora group gave results identical to those of the Eswarakora group rather than of the Muey Nawng -- it was resistant at all sites except at Cuttack and Ranchi. The reaction of the Ptb/Siam 29 cross was identical to that of Ptb -- it was resistant at all sites except at Raipur.

Sri Lanka. Two greenhouse tests were conducted at Peradeniya and 2 field tests at Batalagoda. The Leuang 152 and Ob 677 groups were resistant at Peradeniya and Batalagoda and the Eswarakora group and Muey Nawng/Eswarakora were susceptible. Reactions of the other groups were less distinct -- the reaction varied from one test to another and among entries within a group. In 1977, the Ptb entries were resistant at Peradeniya (Table 3). In 1979 CR94-13 was resistant; most of the others in the Ptb group were moderately resistant or susceptible (Table 5). At Batalagoda, all Ptb entries were resistant (Table 4). The Siam 29, Muey Nawng 62M, and Ptb/Siam 29 groups were generally susceptible at Peradeniya and moderately resistant or resistant at Batalagoda (Tables 3-6).

Table 4. Reaction of entries in the 1978 Collaborative Gall Midge Biotype study.

Designation	Varietal reaction to gall midge[a]						
	Indonesia		Thailand[b]		India		Sri Lanka
	Bogor GH	Sukamandi F	Phrae F	Bangkhen GH	Cuttack F	Hyderabad GH	Batalagoda F
Leuang 152 group							
Leuang 152	R (0)	R (0)	S (17)	MR (10)	R (0)	R (0)	R (0)
CR95-JR-46-1	R (0)	R (0)	S (17)	S (70)	R (0)	R (0)	R (0)
CR95-JR-214	S (100)	S (82)	MR (13)	S (90)	R (0)	R (0)	R (0)
Ptb group							
Ptb 10	S (100)	S (28)	MR (11)	S (90)	R (0)	R (0)	R (0)
Ptb 18	S (100)	S (51)	MR (12)	S (90)	R (0)	R (0)	R (0)
Ptb 21	S (100)	S (83)	MR (12)	S (90)	R (0)	R (0)	R (0)
CR157-392-4	S (100)	S (31)	S (21)	S (90)	R (0)	R (0)	R (0)
CR94-13	S (100)	S (76)	MR (12)	S (90)	R (0)	R (5)	R (3)
IR36	S (100)	S (73)	MR (11)	S (70)	R (1)	R (0)	R (0)
Eswarakora group							
W1263	S (100)	S (49)	R (0)	R (0)	MR (7)	R (0)	MR (7)
Kakatiya	S (100)	S (27)	MR (6)	R (0)	R (2)	R (0)	MR (9)
IET2893	S (100)	S (63)	R (2)	R (0)	MR (14)	R (0)	S (17)
BKN6806-46-60	S (100)	S (63)	R (5)	MR (10)	S (19)	R (0)	S (22)
RD9	S (100)	S (84)	R (0)	R (0)	S (18)	R (0)	S (18)
Siam 29 group							
Siam 29	S (100)	S (58)	MR (13)	S (30)	S (16)	S (100)	S (39)
IET2911	R (0)	MR (7)	S (17)	S (78)	R (1)	R (0)	R (2)
CR189-4	R (0)	S (74)	S (21)	S (100)	R (0)	R (0)	R (4)
Muey Nawng 62M group							
Muey Nawng 62M	S (28)	S (21)	MR (8)	MR (10)	MR (11)	S (100)	MR (6)
Ob 677 group							
Ob 677	R (0)	R (0)	S (18)	S (89)	R (0)	R (0)	R (0)
75-159	R (0)	R (2)	S (17)	S (60)	R (0)	R (0)	R (0)
Muey Nawng 62M/Eswarakora group							
BKNBR1030-11-2	S (100)	S (54)	R (3)	R (0)	MR (14)	R (0)	S (19)
Ptb/Siam 29 group							
IR4744-128-1-3	S (25)	S (63)	S (20)	S (100)	R (1)	R (0)	R (2)
IR8 (susceptible check)	S (100)	S (92)	S (18)	S (100)	S (8)	S (94)	S (90)

[a]Based on percentage (in parentheses) of plants in the greenhouse (GH) or hills in the field (F) infested, except at Phrae where ratings were based on percentage of tillers infested. R = resistant (0-5% infestation), MR = moderately resistant (6-15% infestation), S = susceptible (16-100% infestation). [b]Data for Chieng Rai omitted because of low gall midge population in the field.

CONCLUSIONS AND IMPLICATIONS

Many of the reactions were distinct and definite conclusions as to biotypic reactions can be drawn. For some groups in certain sites reactions were difficult to assess. Variations in reactions within a group and variation within one entry from one year to another made it difficult in some cases to distinctly classify the reactions. Although CR95-JR-46-1 and CR95-JR-214 are sister lines -- both have Leuang 152 as a parent (Table 2) -- the latter was susceptible at Bogor and the former was resistant (Table 4). CR95-JR-46-1 apparently has received 2 genes for resistance from Leuang 152 whereas CR95-JR-214 has only 1 gene. The gene in CR95-JR-214 confers resistance in India where this line was selected but does not confer resistance in Indonesia (Table 4) which has a different gall midge biotype. Muey Nawng 62M was moderately resistant at Batalagoda and susceptible at Peradeniya. This reaction is supported by the 1978 IRGMN data. Further testing is necessary to confirm Muey Nawng reactions in Sri Lanka. These tests would confirm whether the resistance of Muey Nawng 62M is due to different screening techniques (field and greenhouse) or to biotypes. The latter seems unlikely because of the close proximity of Batalagoda and Peradeniya.

Table 5. Reaction of entries in the 1979 Collaborative Gall Midge Biotype study.

Designation	Varietal reaction to gall midge[a]										
	Indonesia		Thailand				India				Sri Lanka
	Bogor GH	Sukamandi F	Chieng Rai F	Phan GH	Bangkhen GH[b]	Bangkhen GH	Raipur F	Cuttack F	Hyderabad GH	Warangal F	Peradeniya GH
Leuang 152 group											
CR95-JR-46-1	R (0)	R (5)	S (78)	S (82)	S (83)	S (53)	R (2)	S (20)	R (0)	R (0)	R (0)
Ptb group											
Ptb 18	S (63)	S (45)	S (35)	S (70)	S (90)	S (20)	S (22)	MR (10)	MR (14)	R (0)	S (40)
Ptb 21	S (61)	S (30)	S (53)	S (63)	S (53)	S (25)	S (21)	R (5)	S (56)	R (0)	MR (11)
CR157-392-4	S (68)	S (25)	S (60)	S (75)	S (79)	S (32)	R (3)	R (0)	R (0)	R (0)	S (41)
CR94-13	S (89)	S (25)	S (63)	S (89)	S (72)	S (85)	S (26)	S (25)	S (20)	R (4)	R (0)
IR36	S (89)	S (30)	S (65)	S (82)	S (77)	S (45)	S (79)	S (30)	R (0)	R (2)	S (19)
Eswarakora group											
W1263	S (64)	MR (10)	R (3)	S (68)	S (22)	S (44)	R (1)	MR (15)	R (0)	R (0)	S (100)
Kakativa	S (81)	S (30)	S (18)	MR (10)	R (0)	S (56)	R (0)	S (80)	R (0)	R (0)	S (100)
IET2895	S (75)	MR (15)	S (48)	S (52)	S (17)	S (20)	S (27)	S (70)	S (70)	R (3)	S (100)
RD9	R (0)	MR (10)	S (16)	S (44)	R (0)	R (5)	R (2)	S (80)	S (38)	R (0)	S (89)
BKN6806-46-60	S (73)	S (20)	MR (15)	MR (7)	S (24)	S (47)	R (1)	S (70)	R (0)	R (0)	S (100)
Siam 29 group											
Siam 29	R (0)	R (0)	S (35)	S (72)	S (70)	S (23)	R (0)	-	R (0)	R (0)	S (67)[c]
IET2911	R (0)	S (35)	S (80)	S (70)	S (92)	S (50)	R (2)	MR (10)	R (0)	R (0)	S (15)
CR189-4	R (0)	S (20)	S (70)	S (82)	S (82)	S (80)	R (4)	R (0)	R (0)	R (0)	S (33)
Muey Nawng 62M											
Muey Nawng 62M	R (0)	R (0)	S (78)	S (54)	MR (9)	S (21)	MR (12)	MR (15)	S (71)	MR (6)	S (100)
Ob 677 group											
Ob 677	R (0)	R (0)	S (88)	S (81)	S (89)	S (78)	R (0)	R (0)	R (0)	R (0)	MR (6)
75-159	R (0)	R (5)	S (90)	S (57)	S (83)	S (47)	R (0)	R (0)	R (0)	R (0)	MR (39)
Ptb/Siam 29 group											
IR4744-128-1-3	S (65)	R (5)	S (83)	S (77)	S (91)	S (53)	S (37)	S (20)	S (71)	MR (14)	S (64)
IR8 (susceptible check)	S (87)	S (26)	S (83)	S (83)	S (76)	S (89)	S (98)	S (70)	S (90)	S (40)	S (100)

[a]Based on percentage (in parentheses) of plants in the greenhouse (GH) or hills in the field (F) infested. R = resistant (0-5% infestation), MR = moderately resistant (6-15% infestation), S = susceptible (16-100% infestation). [b]Conducted at the Entomology and Zoology Division, Bangkhen, with insects collected from Trad Province in eastern Thailand and cultured in Bangkhen for 3 generations. [c]Two replications had 0% infested hills.

Siam 29 was resistant at all sites in Indonesia and India in 1979 (Table 5) but susceptible in other years. The seeds used in 1979 were received from the Rice Division in Thailand while in other years seeds were obtained from IRRI sources. Although we included 5 accessions of Siam 29 from the IRRI world collection in the 1980 study we were not able to identify an accession with resistance. It is apparent that except in 1979 the Siam 29 tested is not the same as that used in breeding the Siam 29 derivatives used in this study.

The gall midge is widely distributed in Asia and Africa and it would be of interest to identify the reaction of the different varietal groups in additional countries. In West Africa, the International Institute of Tropical Agriculture (IITA) conducted a screening trial at Gangnum, Plateau State, Nigeria, in 1976. Ptb 18 and the Eswarakora derivative, W1263 were both resistant (Kaung Zan, IITA, pers. comm.).

The differential reactions of various donor sources to the gall midge at different sites point out the need to clearly determine the reaction and utilize in the breeding program only those sources with resistance. None of the sources can be used for Khonkaen, Thailand, and only one can be used for Ranchi, India. Additional screening must be conducted in these areas to identify sources that can be used in the breeding programs. Several sources can be utilized for Andhra Pradesh, India. Donor varieties that have multiple resistance to gall midge and other pests, such as Ptb 21 which is resistant to the brown planthopper and gall midge in Andhra Pradesh, should be selected. Except at Ranchi, all the Siam 29 derivatives were

Table 6. Reaccion of entries in the 1980 Collaborative Gall Midge Biotype study.

Designation	Varietal reaction to gall midge[a]: China											
	China	Indonesia		Thailand				India			Sri Lanka
	Guangzhou GH	Bogor GH	Sukamandi F	Phan F	Chieng Rai F[b]	Phrae F	Khon-kaen F	Cuttack F	Wara-ngal F	Ranchi F	Batala-goda F
Leuang 152 group											
Leuang 152	R (4)	R (0)	R (5)	S (95)	S (100)	S (100)	S (75)	R (0)	R (0)	S (80)	R (0)
CR95-JR-46-1	R (3)	R (0)	R (0)	S (95)	S (100)	S (100)	S (95)	R (0)	R (0)	S (90)	R (0)
Ptb group											
Ptb 18	S (73)	S (97)	S (95)	S (89)	S (83)	S (100)	S (100)	S (40)	R (4)	S (20)	R (0)
Ptb 21	S (51)	S (90)	S (85)	S (58)	S (100)	S (100)	S (88)	S (75)	R (4)	S (20)	MR (6)
IR36	S (64)	S (100)	S (80)	S (95)	S (100)	S (75)	S (100)	S (85)	S (18)	R (0)	MR (6)
Eswarakora group											
W1263	S (16)	S (94)	S (70)	MR (12)	R (3)	R (0)	S (95)	S (100)	R (2)	R (5)	S (25)
WGL 22585	S (23)	S (100)	S (70)	S (26)	R (3)	–	S (79)	S (100)	R (2)	S (65)	S (88)
Kakatiya	S (49)	S (100)	S (95)	S (44)	–[c]	–	S (80)	S (100)	R (0)	R (0)	S (31)
Siam 29 group											
Siam 29 (Acc 42)	S (57)	S (88)	S (90)	S (85)	S (100)	S (25)	S (94)	S (100)	S (16)	S (95)	S (44)
Siam 29 (Acc 5473)	S (52)	S (99)	S (95)	S (60)	S (100)	–	S (75)	S (100)	S (31)	S (100)	S (25)
Siam 29 (Acc 5915)	S (54)	S (96)	–	S (90)	S (100)	–	S (90)	S (100)	S (26)	S (100)	S (63)
Siam 29 (Acc 5916)	S (60)	S (100)	S (90)	S (89)	S (100)	S (50)	S (84)	S (100)	S (24)	S (100)	S (31)
Siam 29 (Acc 36665)	S (62)	S (99)	S (100)	S (95)	S (47)	S (30)	S (90)	S (100)	S (24)	S (100)	S (75)
IET2911	MR (6)	R (0)	S (20)	S (100)	S (90)	S (30)	S (80)	[illegible] (0)	R (0)	S (60)	MR (13)
Muey Nawng 62M group											
Muey Nawng 62M	S (74)	S (46)	S (35)	S (44)	S (82)	R (3)	S (30)	S (100)	S (21)	S (85)	MR (6)
Ob 677 group											
Ob 677	R (4)	R (0)	S (25)	S (95)	S (62)	S (23)	S (50)	R (0)	R (0)	S (60)	R (0)
BG401-2	R (5)	R (0)	–	S (100)	S (100)	S (58)	S (90)	R (0)	R (0)	S (60)	MR (6)
Muey Nawng 62M/Eswarakora group											
BKNBR1030-11-2	MR (14)	S (100)	S (73)	MR (15)	R (4)	R (3)	S (70)	S (100)	MR (6)	S (25)	S (75)
TN1 (Susceptible check)	S (57)	S (100)	S (100)	S (95)	S (100)	S (100)	S (72)	S (100)	–	S (100)	S (81)

[a]Percentage of plants in the greenhouse (GH) or hills in the field (F) infested. R = resistant (0-5% infestation), MR = moderately resistant (6-15% infestation), S = susceptible (16-100% infestation). [b]Farmer's field. [c]Poor seed germination.

Table 7. Reactions[a] of different varietal groups to the gall midge at various sites.

Designation	Site: China	Indonesia		Thailand				India					Sri Lanka	
	Guang-zhou GH	Bogor	Suka-mandi	Bang-khen	Khon-kaen	Phrae	Chieng Rai	Raipur	Cut-tack	Hyde-rabad	Waran-gal	Ran-chi	Pera-deniya	Batala-goda
Leuang 152 group	R	R	R	S	S	S	S	R	[illegible]	R	R	S	R	R
Ptb group	S	S	S	S	S	S	S	S	R	R	R	S	R[b]	R
Eswarakora group	(S)[c]	S	S	R	S	R	R	R	S	R	R	R	S	S
Siam 29 group	MR	R	S	S	S	S	S	R	R	R	R	S	S	R
Muey Nawng 62M	S	(R)	(MR)	(MR)	S	R	S	(MR)[d]	R	S	S	S	S	R
Ob 677 group (Ptb 18/Eswarakora)	R	R	R	S	S	S	S	R	R	R	R	S	R	R
Muey Nawng 62M/ Eswarakora	MR	S	S	MR	S	R	R	R	S	R	R	S	S	S
Ptb/Siam 29 group	S	S	S	S	S	S	S	S	R	R	R	–[e]	S	R

[a]Based on 1978 IRGMN and 1980 Collaborative Gall Midge Biotype Study data. R = resistant, S = susceptible, MR = moderately resistant. [b]Three entries were susceptible in the 1979 test but all entries were resistant in the 1977 test. [c]Parenthesis indicates that because of variation in ratings further testing is required. [d]Moderately resistant in the 1979 test with 15% hills infested but highly susceptible in the 1978 IRGMN (IRRI 1979b, 1980). [e]Ptb/Siam 29 group not included in the 1980 test which was the only year the study was conducted at Ranchi.

Table 8. Reactions[a] of varietal groups to the gall midge in China, Indonesia, Thailand, Sri Lanka, and 3 sites in India, 1977-80.

Varietal group	Site[a]: China	Indonesia	Thailand	India: Raipur	Hyderabad	Cuttack	Ranchi	Sri Lanka
Leuang 152 group	R	R	S	R	R	R	S	R
Ptb group	S	S	S	S	R	R	S	R[b]
Eswarakora group	R[c]	S	R	R	R	S	MR	S
Siam 29 group	MR	R	S	R	R	R	S	R
Muey Nawng 62M	S	R[d]	MR	S	S	MR	S	S
Ob 677 group	R	R	S	R	R	R	S	R

[a]Based on greenhouse tests in Bogor, Indonesia; Bangkhen, Thailand; Peradeniya, Sri Lanka; and Hyderabad, Indi and on field tests at Raipur and Cuttack, India. Data of 1976-79 IRGMN consulted in determining reactions. R = resistant, S = susceptible, MR = moderately resistant. [b]The reaction of the Ptb group is not well defined, some entries being resistant and others susceptible in a given year to another. However, CR94-13 was resistant in all tests at Peradeniya and Batalagoda, Sri Lanka. [c]Most of the Eswarakora derivatives with W1263 as a parent were resistant in the 1978 IRGMN but were susceptible in the 1980 collaborative project. [d]Resistant in the 1978 IRGMN (IRRI 1979b) and 1977 and 1979 collaborative projects, susceptible in the 1979 IRGMN (IRRI 1980 and 1978 and 1980 collaborative projects.

Table 9. Gall midge biotype classification by varietal reaction.

China biotype	• Eswarakora,[a] Leuang 152, and Ob 677 derivatives resistant • Siam 29 derivatives moderately resistant • Muey Nawng 62M and Ptb derivatives susceptible
Indonesia biotype	• Leuang 152, Siam 29, Muey Nawng 62M, and Ob 677 derivatives resistant • Eswarakora and Ptb derivatives susceptible
Thailand biotype	• Eswarakora derivatives resistant • Muey Nawng moderately resistant • Leuang 152, Ptb, Siam 29, and Ob 677 derivatives susceptible
India (Raipur) biotype	• Leuang 152, Eswarakora, Siam 29, and Ob 677 derivatives resistant • Ptb derivatives and Muey Nawng 62M susceptible
India (Andhra Pradesh) biotype	• Leuang 152, Ptb, Eswarakora, Siam 29, and Ob 677 derivatives resistant • Muey Nawng 62M susceptible
India (Orissa) biotype	• Leuang 152, Ptb, Siam 29, and Ob 677 derivatives resistant • Muey Nawng 62M moderately resistant • Eswarakora derivatives susceptible
India (Bihar) biotype	• Eswarakora derivatives moderately resistant • Leuang 152, Ptb, Siam 29, Muey Nawng 62M, and Ob 677 derivatives susceptible
Sri Lanka biotype	• Leuang 152, Ptb, Siam 29, and Ob 677 derivatives resistant • Eswarakora derivatives and Muey Nawng 62M susceptible

[a]Reaction needs to be confirmed. Resistant in the field in the 1978 IRGMN (IRRI 1979b) but susceptible in the 1980 collaborative project.

Table 10. Reaction of gall midge-resistant varietie to biotypes 1, 2, and 3 of the brown planthopper, green leafhopper, and whitebacked planthopper at IRR (Heinrichs, unpubl.).

Designation	Reaction to[a]: Brown planthopper biotype 1	2	3	Green leafhopper[b]	Whitebacke planthopper[c]
Leuang 152 group					
Leuang 152	S	S	S	S	S
CR95-JR-46-1	S	S	S	S	S
Ptb group					
Ptb 18	R	R	R	R	MR
Ptb 21	R	R	R	R	R
IR36	R	R	MR	R	S
Eswarakora group					
W1263	R	S	R	S	S
Kakatiya	S	S	S	S	S
Siam 29 group					
Siam 29 (Acc 42)	S	S	S	R	S
IET2911	S	S	S	S	MR
Muey Nawng 62M	S	S	S	S	S
Ob 677	S	S	S	S	S

[a]Damage ratings: 1-3 = R (resistant), 5 = MR (moderately resistant), and 7-9 = S (susceptible). [b]*N. virescens*. [c]*S. furcifera*.

consistently resistant in India. However, in Thailand, only the Eswarakora derivatives were resistant and even within the group there was some variation in reactions -- some were susceptible. In the 1979 IRGMN, all entries, including Eswarakora derivatives RD4 and RD9, bred for resistance in Thailand, were susceptible at Khonkaen. Whether this is the result of a selection for a biotype virulent to these varieties is not known. It does suggest the need to utilize several different gene sources in the breeding program so that lines to replace varieties which become susceptible due to selection for a virulent biotype can be available.

Future studies must attempt to decrease the inconsistency of results. For this purpose, development of isogenic lines would be useful (IRRI 1979). Eswarakora seed has been obtained from Warangal, India, and will be included in the 1981 study.

More knowledge about the process of biotype selection in gall midge resistance is needed. It is important to know the rate at which biotypes can be selected on the various resistance sources being utilized in the various breeding programs and elite breeding lines being considered for release.

A better understanding of the inheritance of gall midge resistance and studies on gall midge genetics would increase our ability to understand the biotype selection process and to develop effective breeding strategies which may lead to the release of stable gall midge-resistant varieties.

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